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VALUE IN HEALTH

A Cost-Effectiveness Model Comparing Endovascular Repair to Open Surgical Repair of Abdominal Aortic Aneurysms in Canada

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ABSTRACT

Objectives: The primary risk of abdominal aortic aneurysms (AAAs) is rupture, which is associated with a high mortality rate. Elective surgical options for AAA include open repair (OR) and endovascular aneurysm repair (EVAR). EVAR is less invasive than OR, and therefore may have less surgical risk than OR. However, the graft used for EVAR is much more expensive then the graft used for OR.

Methods: A decision model with a 10-year time horizon was used to assess the cost-effectiveness of EVAR versus OR. The primary outcome measure was quality-adjusted life-years (QALYs). The model incorporated the costs and benefits of both perioperative outcomes and postoperative outcomes. A systematic review was conducted to derive clinical outcome rates. Cost and utility model variables were based on various literature sources and data from a recent Canadian observational study. Parameter uncertainty was assessed using probabilistic sensitivity analysis.

Results: In the base-case model, the incremental cost per QALY of EVAR was estimated to be $268,337, whereas the incremental cost per life-year was found to be $444,129. The incremental cost per QALY of EVAR remained above $295,715 under different assumptions of cohort age and model time horizon.

Conclusions: Based on commonly quoted willingness-to-pay thresholds, EVAR was not found to be cost-effective compared to OR.

Keywords: abdominal aortic aneurysm, cost-effectiveness analysis, endovascular repair, Markov model, open surgical repair.

Introduction

Abdominal aortic aneurysms (AAAs) are a significant health concern in Canada. It is estimated that the prevalence of AAA ranges from 4.1% to 14.2% in men, and between 0.35% and 6.2% in women [1]. In Canada, AAAs are the 10th leading cause of death in men 65 years of age or older. The primary risk of AAA is rupture, which is associated with high mortality rates [2]. As a result of these high mortality rates, surgery is recommended when aneurysms are >5.5-cm diameter, when aneurysms are symptomatic or when there has been a rapid increase in aneurysm size.

Current elective surgical treatment options for AAA include open repair (OR) and endovascular aneurysm repair (EVAR). Endovascular repair is less invasive than OR, which may result in a better quality of life for patients after surgery. Recent randomized controlled trials [3,4] have shown EVAR to have lower 30-day mortality and fewer serious operative complications compared to OR.

As with most new health technologies, there is a trade-off between the costs and benefits of endovascular repair. A recent Canadian hospital-based cost study estimated the cost per EVAR graft to be $9500 compared to $374 for an OR graft [5]. This additional cost may be partially offset by a shorter length of stay. Forbes et al. found the mean length of hospital stay after EVAR to be 5.1 days shorter compared to OR [5]. An additional cost consideration relates to the concern that postprocedural complications may arise after EVAR. These include endoleaks, graft migration, aneurysm rupture, and conversion to OR.

This study evaluates the cost-effectiveness of EVAR versus OR in Canada, using a decision analytic framework. A systematic literature review was conducted to estimate clinical model parameters. Cost and utility model parameters for the model were estimated from various published literature sources along with data from a recent Canadian observational study [6].

Methods

Overview

A probabilistic, decision analytic model was used to estimate the expected costs, life-years, and quality-adjusted life-years (QALYs) associated with two treatment options for elective AAA repair: 1) EVAR and 2) OR. The model cohort is comprised of 70-year-old male patients with >5.5-cm AAAs, who are medically suitable to undergo either EVAR or OR. This specific age was chosen as a recent Canadian study [2] presenting historical data on AAA repair reported that the average age of AAA patients was close to 70 years. The analysis is performed from a third-party health care payer perspective. The time horizon of the model is 10 years, however, alternative time horizons are explored in sensitivity analysis. Both costs and outcomes were discounted at 3% annually. The overall approach of the analysis will be, first, to determine whether one strategy is dominant (lower costs, more QALYs) over the other. In the absence of dominance, an incremental cost-effectiveness ratio will be calculated and expressed as an incremental cost per QALY gained.

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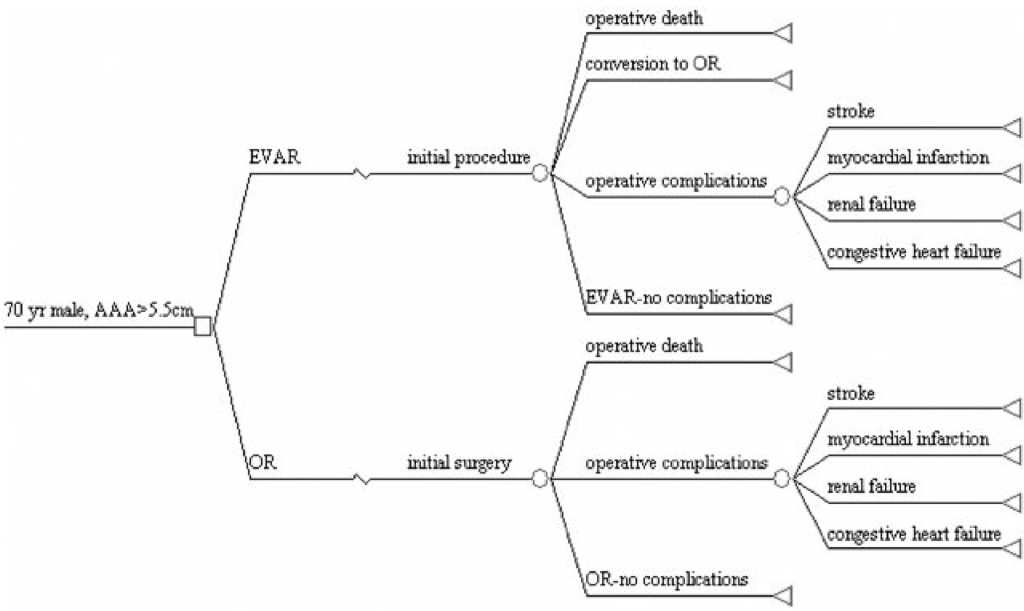

Figure 1 Structure of 30-day postoperative decision tree.

Model Structure

The model includes both a 30-day postoperative phase and a long-term Markov model phase. The structure of the short-term phase of the model is shown in Figure 1. During the 30-day postoperative phase, both treatment arms are at risk for operative death and postoperative complications. In addition, the EVAR treatment arm is at risk for conversion to OR along with endoleaks. Four postoperative complications with associated long-term cost, mortality, and morbidity impacts were included in the model. These complications were stroke, myocardial infarction (MI), renal failure, and congestive heart failure (CHF). The proportion of patients suffering a complication or operative death differs between the OR and EVAR treatment arms. The 30-day model phase estimates the expected costs of the index hospitalization along with expected QALYs over 30 days for the two treatment arms.

Figure 2 displays the long-term phase of the model. The long-term phase is structured as a Markov model with cycles of 3 months in duration. Patients transition between a number of health states during each cycle. Patients who suffer a postoperative complication continue in a single "alive" health state until they die. Separate probabilities of death, utility values, and costs are assigned to the stroke, MI, renal failure, and CHF "alive" health states. Patients in the EVAR treatment arm who did not have a postoperative complication transition between the four health states in the long-term model. These long-term health states are aneurysm rupture, endoleak, conversion to OR, death, and post-EVAR no events. Patients who do not immediately die after rupture are converted to OR and are at risk for postoperative complications. Patients in the OR treatment group without a postoperative complication transition between aneurysm rupture, death, and post-OR no-events health states. There are unique costs and QALYs associated with each health state.

Model Input Parameters

Various sources were used for the model input parameters. A systematic literature review was conducted to identify studies that estimate the 30-day clinical outcomes such as postoperative death and complication rates for the two treatment arms. Long-term model parameters were derived from a combination of our primary systematic review, peer-reviewed studies, government publications, and administrative databases. A substudy using data from an observational Canadian study was conducted to estimate the cost of the index hospitalization [6].

A systematic literature review was conducted to identify studies that derive 30-day postoperative and certain long-term clinical model parameters (endoleaks, conversion to OR, and aneurysm rupture). The initial literature search identified 3946 unique citations with EVAR or OR in their title or abstract. The final screen of articles revealed 84 unique primary studies comparing EVAR to OR (six randomized control trials [RCTs] and 78 observational studies). These studies formed the basis of the data used for the clinical model parameters. Analyses were performed separately for the RCT studies and for the observational studies. When available, estimates from the RCT studies were used in the model. When outcomes were reported in more than one study, pooled estimates of the probabilities of events were made separately for EVAR and OR. Pooling was carried out using random effects inverse variance weighting techniques [7]. Data from RCTs were available for all model variables except for postoperative stroke and annual long-term conversion from EVAR to OR estimates.

Annual mortality rates for the long-term part of the model were derived from a number of sources. The annual probability of death for all causes by age was based from the Statistics Canada life tables [8]. It was assumed that patients who were treated for AAA would have a higher risk of death compared to the general population. The long-term relative risk of death for AAA patients compared to the general population (i.e., relative risk, 1.3) was based on reported findings from a recent Canadian study [6]. The probability of death after rupture was based on a study by Harris et al. [9]. The absolute risk of death post-MI and poststroke was based on studies by Kapral et al. [10] and Rouleau et al. [11], respectively. The relative risk of death after CHF and renal failure was taken from a study by Herzog et al. [12].

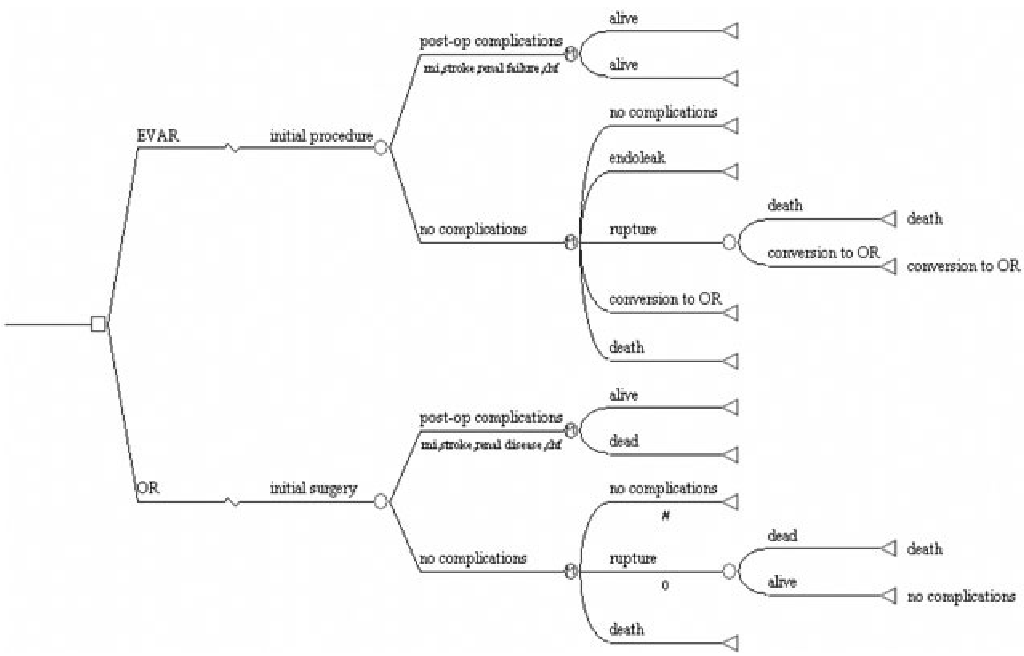

Figure 2 Structure of long-term Markov model.

Based on data collected for a Canadian observational study [6], a substudy was conducted to estimate the costs of the index hospitalization for the EVAR and OR treatment arms. In this substudy, detailed inpatient costing records were obtained from a southern Ontario hospital for consecutive patients undergoing either elective EVAR (n = 140) or OR (n = 195) from August 2003 to April 2005. Total hospital costs included those related to the aneurysm procedure and device, other tests and procedures, length of stay, and drugs. Surgeons' and anesthetists' fees related to the OR and EVAR procedures were added based on the Ontario Schedule of Physician Benefits [13].

For each hospitalization, data were available on any postoperative complications that occurred. The entire cohort of each strategy in the model was assigned the mean costs of hospitalizations in which a postoperative complication (stroke, MI, CHF, and renal failure) did not take place. The proportion of the model cohort that incurred a complication was assigned additional costs for their index hospitalization. These additional costs were based on further analysis of the patient cost records. Specifically, the additional hospital costs were estimated using an ordinary least squares regression model. In this model, patient hospital cost was specified as the dependant variable, whereas indicator variables for treatment, postoperative death, and other postoperative complications (stroke, MI, CHF, and renal failure) were specified as dependant variables. This provided an estimate of the additional cost of having each complication during the initial hospitalization.

A number of cost variables were used for the long-term phase of the model. Based on expert opinion of a vascular surgeon, it was assumed that EVAR patients would be followed up with one computed tomography (CT) scan annually. Therefore, the annual follow-up cost of EVAR included the costs of one CT scan and one vascular surgeon assessment. The cost of CT scan was provided by a teaching hospital in southern Ontario. The cost of a vascular surgeon assessment was derived from the Ontario Schedule of Physician Benefits [13]. No annual follow-up costs were assigned to OR patients. The cost applied to aneurysm rupture repair was based on the mean cost of rupture repair hospitalization found in the Ontario Case Costing Initiative database [14]. The cost of an endoleak intervention was based on the cost for an embolization reported in a recent Canadian study [5]. The annual costs of postmajor complications (MI, CHF, stroke, and renal failure) were derived from various Canadian literature sources. The annual cost of CHF was based on a study by Tsuyuki et al. [15] in which the 6-month cost of hospitalized patients with heart failure was estimated. The annual cost after MI was derived from an unpublished study by Coyle et al. The annual costs after renal failure and stroke were derived from Kroeker et al. [16] and Riviere et al. [17], respectively.

Background utility values by age were based on general population utility values for males estimated by Kind et al. [18]. Differences in utility values between EVAR and OR were based on data reported in the EVAR-1 study [3]. In this study, the mean EQ5D index utility scores were reported for patients randomized to either EVAR (n = 543) or OR (n = 539) at various time periods. Specifically, utility values were reported at baseline, from months 0 to 3, from months 3 to 12, and from months 12 to 24. Utility decrements were applied to background utility values and were used to estimate the mean utility for the time periods used in our model. During the long-term phase of the model, the proportion of the treatment cohorts that had suffered a postoperative complication was assigned further utility decrements. The utility weights assigned to the various disease states are shown in Table 1. The utility weights for stroke and MI health states were derived from Schleinitz and Heidenreich [19] and Oldridge et al. [20], respectively. The utility weights for renal failure and CHF health states were derived from Revicki [21] and Lewis et al. [22]. These weights were multiplied by the no-complications daily utility weight for each treatment group.

Calibrating Long-Term Survival Estimates

The all-cause long-term mortality reported in the Dutch Randomized Endovascular Aneurysm Management (DREAM) and EVAR-1 trials were reviewed and used to calibrate the long-term

Table 1 Annual long-term model inputs

Model variable	Point estimate	Distribution
Conversion from EVAR to OR	0.66%	Beta ($\alpha = 49.7$, $\beta = 7{,}486.26$)
Endoleaks	2.6%	Beta ($\alpha = 24.4$, $\beta = 912.2$)
Rupture (EVAR)	0.8%	Beta ($\alpha = 24.8$, $\beta = 3{,}075.26$)
Rupture (OR)	0%	—
Mortality		
All causes	Depends on age	—
Relative risk (general population)	1.3	—
After rupture	65%	Beta ($\alpha = 9.3$, $\beta = 5.0$)
MI	5.3%	Beta ($\alpha = 168.4$, $\beta = 3{,}010$)
Stroke	12%	Beta ($\alpha = 350.9$, $\beta = 2{,}573.1$)
Renal failure (relative risk)	2.24	Lognormal ($\mu = 0.81$, $\alpha = 0.008$)
CHF (relative risk)	1.64	Lognormal ($\mu = 0.81$, $\alpha = 0.008$)
Costs ($)		
Follow-up costs (EVAR)	352	Gamma ($\alpha = 25$, $\beta = 14.1$)
Rupture repair	17,212	Gamma ($\alpha = 25$, $\beta = 688.5$)
Endoleak repair	900	Gamma ($\alpha = 25$, $\beta = 36.0$)
Stroke	15,690	Gamma ($\alpha = 25$, $\beta = 627.6$)
MI	5,566	Gamma ($\alpha = 25$, $\beta = 222.6$)
Renal failure	57,314	Gamma ($\alpha = 25$, $\beta = 2{,}292.6$)
CHF	9,096	Gamma ($\alpha = 25$, $\beta = 363.8$)
Background utility by age		
<55	0.84	—
55–64	0.78	—
65–75	0.78	—
>75	0.75	—
Utility weights		
No complications	0.71	Beta ($\alpha = 385.3$, $\beta = 157.5$)
Stroke	0.39	Beta ($\alpha = 39$, $\beta = 61$)
MI	0.77	Beta ($\alpha = 77$, $\beta = 23$)
Renal failure	0.63	Beta ($\alpha = 63$, $\beta = 37$)
CHF	0.64	Beta ($\alpha = 64$, $\beta = 36$)

EVAR, endovascular aneurysm repair; OR, open repair; MI, myocardial infarction; CHF, congestive heart failure.

mortality estimates of the model. Specifically, the long-term mortality rates used in the model for OR and EVAR were modified in order for cumulative mortality rates for OR and EVAR to reflect the trials' findings. Long-term mortality was assumed to remain identical for both OR and EVAR after convergence. Furthermore, the long-term costs and utility decrements associated with postoperative complications (i.e., stroke, MI, renal failure, and CHF) were limited to the time when cumulative mortality rates converge.

Sensitivity Analysis and Parameter Uncertainty

One-way sensitivity analyses were performed to assess the impact of a number of structural assumptions and alternative patient subgroups on the model results. Specifically, the model was run with alternative time horizons, starting ages, postoperative complication rates, reintervention costs, long-term utility values, and discount rates.

Parameter uncertainty is addressed by means of probabilistic sensitivity analysis (PSA). In PSA, model variables are assigned distributions of values around their mean instead of single-point estimates. The model is run many times in what is referred to as Monte Carlo simulations. Each time the model is run, a different set of values from all model parameters is chosen based on the specified distributions and a set of random numbers. Different expected costs and outcomes are estimated in each simulation. When the model is run many times, an assessment of the impact of parameter uncertainty of all model variables on cost-effectiveness can be made. Parameter uncertainty is expressed as cost-effectiveness acceptability curves (CEACs). CEACs present the probability that a treatment is cost-effective than its comparators as a function of willingness to pay (WTP) for the outcome of interest.

In the current model, beta distributions were assumed for all probability and utility variables. Gamma distributions were assumed for all cost variables, whereas lognormal distributions were assumed for all relative risk parameters.

Results

Model Input Variable Values

Table 2 provides a summary of the model input parameters used in the 30-day short-term phase of the model. Table 1 provides a summary of the model input parameters used in the long-term Markov phase of the model. As shown in Table 2, estimates of postoperative mortality are 1.47% for EVAR and 4.4% for OR. The probability of postoperative complications is estimated to be higher for OR compared to EVAR. The biggest difference is found in MI and CHF. The probability of both postoperative complications is estimated to be 5.3% for OR compared to 3.5% for EVAR. The utility decrement for OR applied in the 30-day phase of the model was 0.06 (0.73 for EVAR and 0.67 for open surgical repair [OSR]).

The cost of a hospitalization for EVAR in the absence of complications was estimated to be $26,985, whereas the cost for a hospitalization for OR was estimated to be $15,358. If patients incurred a postoperative complication, additional costs were added. For example, the additional hospital cost of having postoperative renal failure was estimated to be $32,537. Therefore, the costs assigned to the proportion of the cohort with postoperative renal failure in the OR arm would be $47,895 ($15,358 + $32,537).

As shown in Table 1, findings from our systematic review were used to estimate the annual probability of EVAR treatment arm experiencing endoleak, converting to OR, and for both treatment groups experiencing an aneurysm rupture. Based on

Table 2 Thirty-day postoperative model inputs

Model variable	Point estimate	Distribution
Postoperative death (EVAR)	1.47%	Beta ($\alpha = 11.7$, $\beta = 777.1.8$)
Postoperative death (OR)	4.%	Beta ($\alpha = 32.9$, $\beta = 714.9$)
Conversion from EVAR to OR	1.8%	Beta ($\alpha = 13.8$, $\beta = 753.4$)
Postoperative complications		
Stroke (EVAR)	0.1%	Beta ($\alpha = 1.2$, $\beta = 1{,}232.1$)
Stroke (OR)	0.15%	Beta ($\alpha = 24.9$, $\beta = 16{,}617.7$)
MI (EVAR)	3.5%	Beta ($\alpha = 24.1$, $\beta = 665.1$)
MI (OR)	5.3%	Beta ($\alpha = 23.3$, $\beta = 423.0$)
Renal failure (EVAR)	0.0%	—
Renal Failure (OR)	0.57%	Beta ($\alpha = 24.9$, $\beta = 4{,}336.1$)
CHF (EVAR)	3.5%	Beta ($\alpha = 24.1$, $\beta = 665.1$)
CHF (OR)	5.3%	Beta ($\alpha = 23.6$, $\beta = 423.0$)
Utility weights		
Utility decrement for OR	0.06	Beta ($\alpha = 38.1$, $\beta = 504.91$)
Hospitalization costs ($)		
No postoperative complications (EVAR)	26,985	Gamma ($\alpha = 25$, $\beta = 1{,}079.4$)
No postoperative complications (OR)	15,358	Gamma ($\alpha = 460.6$, $\beta = 33.3$)
Renal failure	Add 32,537	Gamma ($\alpha = 25$, $\beta = 1{,}301.4$)
CHF	Add 3,211	Gamma ($\alpha = 1.1$, $\beta = 2{,}927.7$)
MI	Add 755	Gamma ($\alpha = 0.03$, $\beta = 23{,}485.2$)
Stroke	Add 10,908	Gamma ($\alpha = 0.54$, $\beta = 19{,}906.3$)
Death	Add 15,916	Gamma ($\alpha = 8.1$, $\beta = 1{,}969.6$)

EVAR, endovascular aneurysm repair; OR, open repair; MI, myocardial infarction; CHF, congestive heart failure.

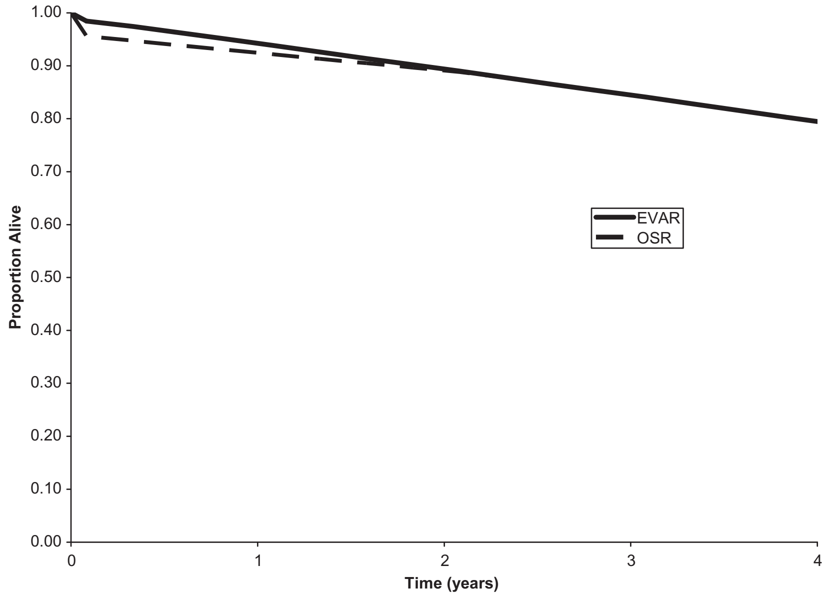

Figure 3 Survival predicted by model.

the meta-analysis, the model assumed the annual probability of rupture to be 0% for the OR treatment arm and 0.8% for the EVAR treatment arm. The model assumed the annual probability of endoleaks to be 2.6%, and the probability of conversion from EVAR to OR to be 0.66%. Although the DREAM study [23] found the mean utility for OR to be slightly higher than EVAR (0.72 vs. 0.71), no utility decrement was applied. In sensitivity analysis, OR was assumed to have 0.01 higher utility than EVAR during the long-term phase of the model. The cost of an aneurysm rupture is estimated to be $17,212. The annual cost of MI, CHF, stroke, and renal failure was estimated to be $5,566, $9,096, $15,690, and $57,314, respectively.

Calibrating Long-Term Survival Estimates

Survival beyond 1 year was reported in both the EVAR-1 [3] and the DREAM [23] trials. Both trials found that cumulative all-cause mortality for EVAR and OR converged after approximately 2 years. Based on these findings, we calibrated the long-term all-cause mortality rate of OR so that cumulative mortality rates for the two groups converge at 2 years. Figure 3 presents the cumulative survival rates over time for EVAR and OR predicted by the model, assuming a starting cohort of 70-year-old males. As shown in this Figure, the model predicts that cumulative survival is identical for OR and EVAR after 2 years. The four-year cumulative mortality predicted by the model was 21% for both EVAR and OR groups, which compares to a four-year mortality of 26% as reported in EVAR-1. This difference is mainly due to the age of model entry. If the model cohort is assumed to be 74 years old (average age in EVAR-1) instead of 70 years of age, the four-year predicted mortality rate becomes 27%.

Cost-Effectiveness Results

Base-case. Expected costs, life-years, and QALYs for the EVAR and OR treatment arms are presented in Table 3. Over a time horizon of 10 years, the expected cost of EVAR was estimated to be $31,908, whereas the expected cost of OR was estimated to be $18,522. The EVAR treatment arm was estimated to produce 0.03 more life-years and 0.05 more QALYs compared to OR. Using life-years gained as the outcome measure, the incremental cost-effectiveness of EVAR was estimated to be $444,129. The incremental cost per QALY was estimated to be $268,337. Figures 4 and 5 present the cost-effectiveness acceptability curves for the cost per life-year gained and the cost per QALY gained outcomes. Based on the life-years outcome, the probability that EVAR is cost-effective is 0.02 at a WTP threshold of $50,000 per life-year, and 0.03 at a WTP threshold of $100,000 per life-year. Based on the QALY outcome, the probability that EVAR is cost-effective is 0.03 at a WTP threshold of $50,000 per QALY, and 0.07 at a WTP threshold of $100,000 per QALY.

Sensitivity analyses. Cost-effectiveness results based on a number of sensitivity analyses are presented in Table 4. Changing the time horizon has a relatively small impact on cost-effectiveness. Using a 5-year time horizon, the expected cost per QALY is estimated to be $240,355. If the time horizon is

Table 3 Base-case results

	Expected values			ICER	
Treatment arm	Costs ($)	LYs	QALYs	$ per LY	$ per QALY
EVAR	31,908	6.631	5.063	—	—
OR	18,552	6.601	5.014	—	—
Incremental (EVAR/OR)	13,355	0.030	0.050	444,129	268,337

EVAR, endovascular aneurysm repair; OR, open repair; LY, life-years; QALY, quality-adjusted life-year; ICER, incremental cost-effectiveness ratio.

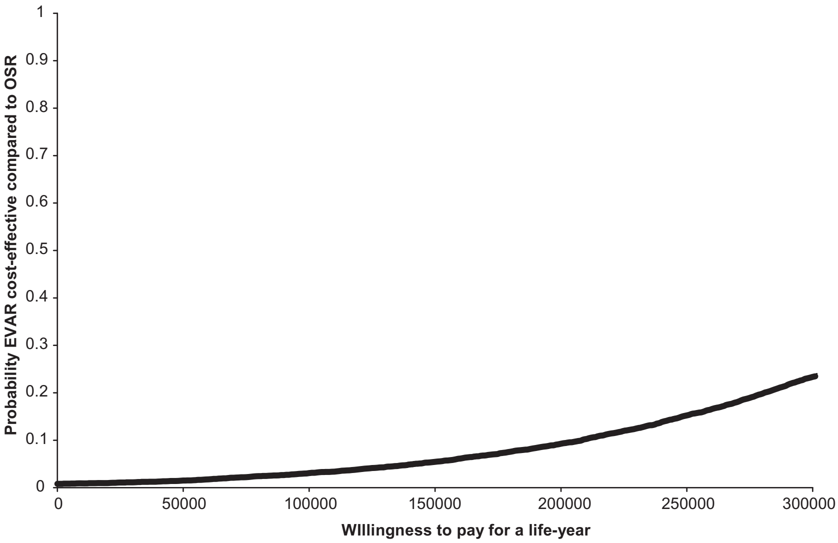

Figure 4 Cost-effectiveness acceptability curve (life-years gained).

extended to 20 years, the incremental cost per QALY of EVAR is $287,257.

The starting age of the cohort had a marginal impact on cost-effectiveness results. The cost per QALY for EVAR when the starting cohort is assumed to be 50 years old is $247,006, whereas the cost per QALY assuming an 80-year-old starting cohort is $363,148. Changing the discount rate used in the model had a minimal impact on model results.

If the 30-day postoperative complication rates for EVAR are assumed to be the same as the OR rates, the cost per QALY is $503,335. If the long-term utility value for OR is assumed to be 0.01 higher than it is for EVAR, OR becomes dominant (more QALYs, less costs) compared to EVAR. If it is assumed that all endoleak interventions would require a complete EVAR redo (i.e., using a cost of $26,985 instead of $900), the incremental cost per QALY of EVAR compared to OR becomes $349,450.

Discussion

Our model provides a Canadian specific assessment of the long-term cost-effectiveness of elective endovascular repair of aortic aneurysms compared to elective OR. There are a number of strengths to our current analysis. Key clinical model parameters (30-day postoperative death and complication rates, annual rupture, annual endoleak, and annual conversion to OR rates) were determined primarily through a formal systematic review and meta-analysis of recently published RCTs. In the absence of RCTs, nonrandomzied data were used. Cost variables used in the model were all based on Canadian studies including a recent observational study of patients undergoing EVAR and OSR of AAAs. In addition, uncertainty surrounding the values of the model parameters was incorporated and assessed using a comprehensive probabilistic analysis.

In our base-case analysis, we estimated the incremental cost per QALY of EVAR to be $268,337. Based on common WTP thresholds, this would not be considered cost-effective. Our findings are similar to other recent economic models comparing elective EVAR to OR of AAAs. For example, Michaels et al. [24] found the incremental cost-effectiveness of EVAR compared to OR to be £110,000 per QALY in patients suitable for OR. Based on a currency exchange rate of £2.03 per CDN$1 (May 29, 2008), this is equivalent to CDN$223,225 per QALY, a close

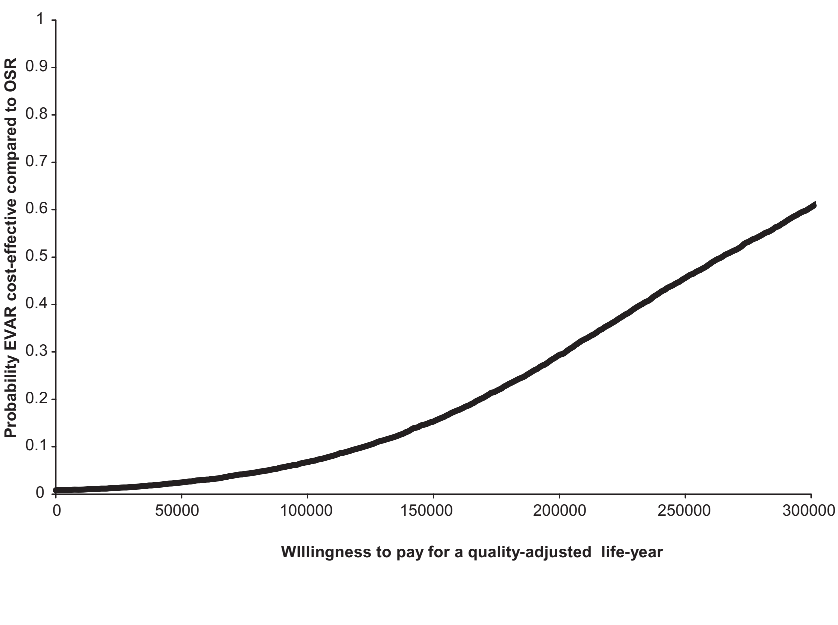

Figure 5 Cost-effectiveness acceptability curve (quality-adjusted life-years gained).

Table 4 Sensitivity analysis

Treatment arm	Incremental (EVAR-OR) Costs ($)	LYs	QALYs	ICER $ per LY	$ per QALY
Model time horizon (year)					
3	11,148	0.0306	0.050	370,739	223,996
5	11,963	0.030	0.050	397,815	240,355
20	14,297	0.030	0.050	475,444	287,257
Starting age					
50 years old	14,179	0.036	0.0574	3,973,519	247,006
60 years old	13,921	0.035	0.053	402,084	262,559
80 years old	12,373	0.010	0.034	1,204,982	363,148
30-day postoperative complication rates					
EVAR rates same as OR	14,575	0.029	0.029	498,572	503,335
Long-term utility rates					
OR utility 0.01 higher than EVAR	13,355	0.030	−0.015	444,129	OR dominates EVAR
Cost of intervention for endoleak					
Assume same cost as index EVAR hospitalization	17,392	0.030	0.050	578,381	349,450
Discount rate					
5%	13,116	0.03	0.049	438,112	265,483

EVAR, endovascular aneurysm repair; OR, open repair; LY, life-years; QALYs, quality-adjusted life-years; ICER, incremental cost-effectiveness ratio.

estimate to our results. Based primarily on results from the EVAR-1 trial, Epstein et al. [25] found OR to dominate (less costs, more QALYs) EVAR. However, the Epstein model predicted that cumulative mortality was slightly higher for EVAR patients than for OR patients after 2 years, which may explain that OR had higher expected QALYs than OR. In contrast, we assumed that overall mortality was identical after 2 years. Another difference between our model and Epstein's model is related to the way costs and utilities of nonstroke postoperative complications are modeled. Specifically, we included MI, CHF, and renal failure in our model. We also relied on several sources of evidence to populate our model.

Two older economic models found EVAR to be much more cost-effective than what was estimated by our model. Bosch et al. [26] estimated the lifetime cost-effectiveness of EVAR to be $9905 per QALY in a cohort of 70-year-old males with 5- to 6-cm AAA. Because the large RCTs at the time were not yet published, the clinical model variables used in Bosch's model were based on meta-analyses of observational studies. In an earlier study, Patel et al. [27] estimated the long-term cost per QALY of EVAR to be $22,826. As there was no published evidence on comparative intermediate/long-term survival of EVAR and OR patients at the time of these models, cumulative mortality for OR and EVAR was not assumed to converge at a particular point in time.

Like most economic models, our current model has a number of limitations. While our model used age-specific utility and mortality rates, complication rates associated with OR and EVAR are age independent because of a lack of evidence, which may impact the results. As shown in our sensitivity analysis, cost-effectiveness results did not change under various scenarios (e.g., time horizon, starting age, and utility). Although we cite the use of a systematic review of RCTs as a strength of our analysis, the use of these data can also be considered a limitation because the patient mix in these studies may have included patients at a low and high risk of postoperative mortality and morbidity. There is recent evidence that EVAR may be cost-effective compared to OSR in high-risk patients [28]. In Canada, EVAR is recommended for patients at an intermediate to high risk of postoperative morbidity and mortality. For patients at a low risk, OSR remains the standard of care [29]. Other limitations of this analysis include the reliance of a single source for utility values after aneurysm repair (assuming no complications) for the two treatment groups, and the reliance of using a single hospital for the source of costs of the initial hospitalization. Despite these limitations, we believe our economic evaluation comparing different treatments for AAA repair provides useful information for decision-makers.

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Supporting information

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